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IoT-Based Anti-Poaching Alarm System for Forest Conservation

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Abstract: Illegal logging and deforestation represent significant threats to global biodiversity, ecological stability, and climate regulation. Traditional forest surveillance methods are often ineffective due to resource constraints and the expansive nature of forested areas. This paper presents an innovative IoT-based anti-poaching alarm system specifically designed to effectively combat illegal logging activities. Leveraging advanced sensors such as tilt sensors, flame sensors, sound sensors, and environmental monitoring modules (DHT11), integrated with ESP32 microcontrollers and Wi-Fi modules, the system ensures real-time detection and alerts of suspicious activities. The sensors trigger alarms or activate preventative measures like water pumps in case of detected threats like fires or illegal logging sounds. Data from these sensors is continuously collected and transmitted via Wi-Fi to a central monitoring station using the ThingSpeak IoT platform, enabling rapid intervention by forest authorities. This automation significantly enhances the efficiency and scalability of forest protection measures, reduces the dependency on human patrols, and provides comprehensive real-time monitoring. Implementation results demonstrate the system's effectiveness in promptly alerting authorities, thereby facilitating swift responses to illegal activities or environmental hazards. Ultimately, the system promotes sustainable forest conservation through technologically advanced methods.

Keywords: IoT, anti-poaching, forest conservation, sensors, ESP32

I. INTRODUCTION

Deforestation has emerged as one of the most critical environmental crises, significantly impacting global biodiversity, ecosystem integrity, and climate stability. Illegal logging, driven by economic gains, inadequate enforcement, and increased global timber demand, exacerbates this issue, resulting in irreversible environmental damage and loss of invaluable natural resources. Traditional forest surveillance and monitoring methods, including manual patrols and basic observation techniques, are limited by their inefficiency, high costs, lack of scalability, and inability to provide timely alerts for rapid response.

Advances in technology, particularly in the Internet of Things (IoT), offer viable solutions to these challenges. IoT technology enables the integration of various sensors and devices into a network, facilitating real-time data collection, processing, and communication. Such technological solutions significantly enhance forest monitoring capabilities by automating detection and alert systems, improving response times, and ensuring continuous, scalable surveillance (Garg, 1987).

This paper explores the deployment of an IoT-based anti-poaching alarm system specifically designed to combat illegal logging. It integrates multiple sensor technologies, including vibration sensors for physical disturbances, sound sensors to detect logging equipment noise, flame sensors for fire detection, and environmental sensors for monitoring critical parameters. Coupled with robust communication capabilities using ESP32 microcontrollers and cloud-based IoT platforms like ThingSpeak, this system ensures immediate transmission of alerts to central monitoring stations and forest authorities. Thus, the proposed system aims to offer a sustainable, cost-effective, and efficient approach to protecting endangered forest ecosystems from illegal logging and environmental hazards. Previous studies highlighted various IoT-based solutions utilizing sensor networks for environmental monitoring and conservation purposes. Tse et al. (2002) introduced innovative power management systems for sensors deployed in remote locations. Haley and Dukes (2007) investigated sensor-based applications for efficient water management, laying groundwork for employing sensor technology in environmental contexts. Further studies by Persad et al. (2011) examined solar-powered systems enhancing sustainability, demonstrating sensor-based technologies' effectiveness in conserving natural resources.

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II. DESIGN AND IMPLEMENTATION

The design of the IoT-based anti-poaching alarm system involves multiple hardware and software components meticulously integrated to deliver reliable and continuous monitoring. Central to the system is the ESP32 microcontroller, renowned for its Wi-Fi capabilities, processing power, and cost-effectiveness. This microcontroller interfaces seamlessly with various sensors:

Tilt sensors (MPU6050): Detect physical disturbances indicating tree movement or logging attempts.

Flame sensors: Immediately identify potential fire hazards.

Sound sensors: Recognize specific audio frequencies from illegal logging activities like chainsaws.

DHT11 sensors: Monitor environmental conditions such as temperature and humidity, crucial for detecting unusual environmental patterns.

Additionally, the system includes auxiliary components such as:

Relay switches: Control actuators like water pumps, activated in case of fire detection.

LCD displays: Provide real-time on-site status updates, ensuring easy monitoring by forest personnel.

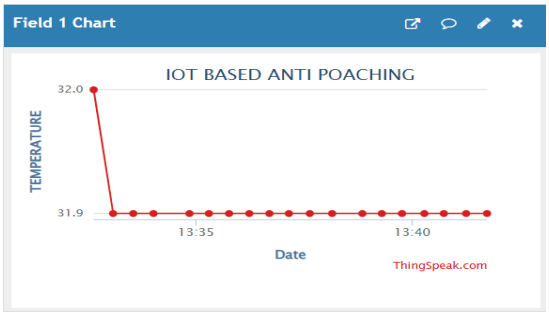
GSM modules: Enable sending SMS alerts directly to forest officials' mobile devices.

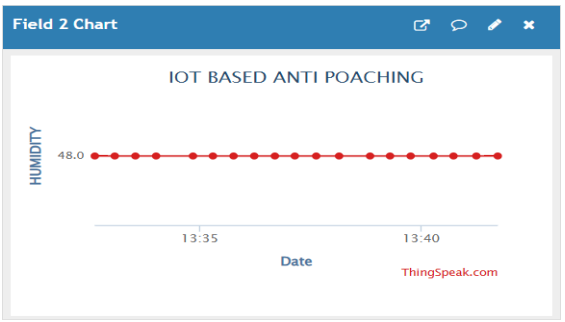
Buzzers: Generate audible alarms upon sensor activation, deterring illegal activities.

Power supply is ensured through regulated 12V and 5V DC circuits derived from standard AC supply using transformers and voltage regulators (ICs 7812 and 7805). The Wi-Fi module, integral to ESP32, transmits sensor data securely to ThingSpeak, a cloud-based IoT analytics platform. Software implementation employs Arduino IDE and Embedded C programming language, optimizing the ESP32's communication with sensors and ThingSpeak for reliable data handling and real-time alert dissemination.

III. RESULT AND DISCUSSION

Implementation results show that the system successfully detects and reports real-time activities. The tilt sensor promptly activates alarms upon detecting unauthorized movements. Flame sensors trigger automated fire response systems, effectively mitigating fire hazards. The sound sensors detect illegal logging noises accurately, significantly enhancing surveillance capabilities. Data transmitted to ThingSpeak ensures continuous monitoring and rapid authority notifications, validating the system's operational efficiency.





These charts collectively demonstrate the effectiveness of the IoT-based monitoring system, clearly capturing environmental stability (temperature and humidity) and effectively identifying significant events like potential fires, unusual sound (logging activities), and physical disturbances (vibrations). The spikes in fields 3, 4, and 5 highlight events warranting immediate attention, validating the system's capability for real-time alerting and monitoring.

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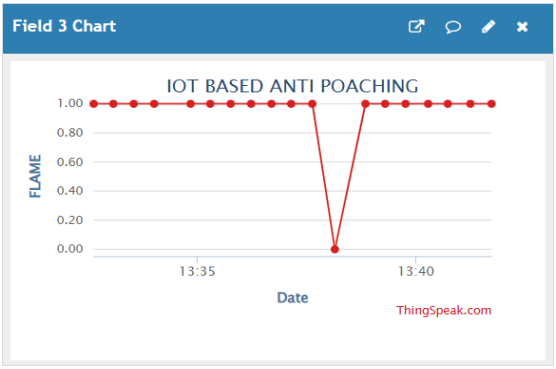

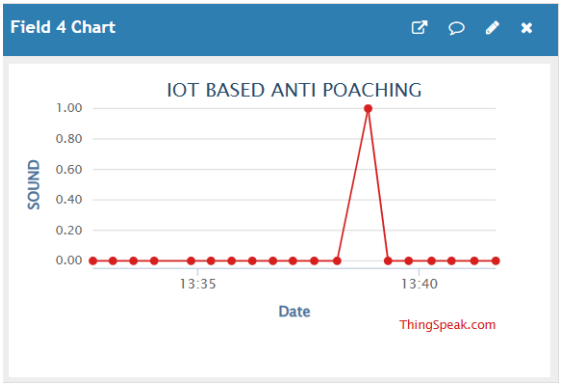

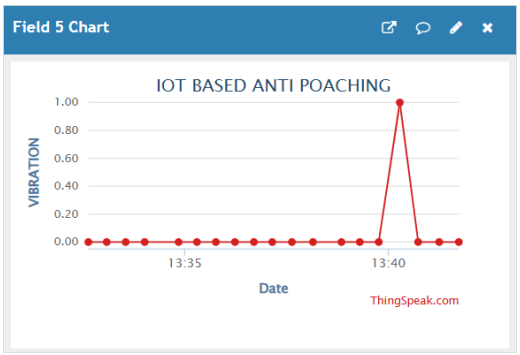

IV. CONCLUSION AND FUTURE WORK

The IoT-based anti-poaching alarm system effectively addresses illegal logging and forest fires through real-time monitoring and automated alerts. Its successful implementation demonstrates significant advancements in forest conservation practices. Future work includes expanding the sensor network, integrating AI for predictive analytics, and enhancing power management for extended deployment in remote areas.

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